Content Management Systems using Quality Transition Mode in Video Content Utilization Services

Mei KODAMA[* **]
[*]Graduate School of Integrated Arts and Sciences,
Hiroshima University
[**] Information Media Center,
Hiroshima University
1-7-1-C112 Kagamiyama Higashi-Hiroshima, 739-8521 JAPAN
mei@hiroshima-u. ac. jp

Abstract—**Thanks to the recent improvements in speed and capacity of data networks, we observe a proliferation of network video content services. From the user's perspective more video requires more memory. To address this problem, we propose a new content management that uses cached delivery and scalable content. Our approach uses a data transition process of scalable structure, and is based on elapsed time and content usage parameters. We present the analysis of the efficiency of the new model.**

Keywords-Content Management Method; On-Demand Services; Video Data Structure; Data Transition; Video Quality.

I. INTRODUCTION

In recent years, video content delivery services by Video On-Demand: VoD are beginning to spread by the popularization of network and improvement of the speed. Moreover, the environment to play videos always is ready without accumulating in user terminals for these services, considering copyright. Generally speaking, in every aspect of content services, there some issues to enhance the efficiency of network management and content management. For examples, the way to solve the delay caused by collisions and retransmitting for large number of contents, the data management schemes and the prioritized transmission for multi-quality contents in heterogeneous environment to play them. There are some content provider sites, such as NicoNico-Douga [1] and YouTube [2]. Users, who are interested in the new content service using the network and streaming services by on-demand, are driving force of a service popularization. However, to solve the problems of the compatibility and the cooperation among some service systems is still insufficient, and there are some problems when they use their service in different systems. Considering the continuity of content services, an information management is one of the important tasks of communication technologies for their services. When the number of used contents exceeds a predetermined level, they have any problem because of the limitation of disk capacity. For example, it becomes very difficult to grasp the whole situation if the time passed, after they moved the content data to the external device. In other words, as they manipulate the information, which is beyond the ability of our memory because of the spread of the digital environment to make our communities more livable, we can say that there is a limit in the information management.

To increase the satisfaction of users for their services, the reduction of content providing costs and the service time is required. Thus, the problem of pricing method and the high efficiency of contents distributed systems based on the priority orders had been studied [3][4]. On the other hand, we had studied about the cache delivery method considering the priority for each content [5] and content management system using scalable architecture [6]. In this paper, we paid attention to the contents management method in contents services of multiple qualities, and present the method using scalable structure and distribution systems supported quality. In this study, we propose video content management methods for multiple qualities. The overview of proposed schemes and the utilization models are explained. Finally, the efficiency is considered.

II. PROPOSED MANAGEMENT METHOD

When the opportunity to use the content service increases, the management method is one of the important problems in video content distributed systems. In order to be able to play contents of multiple qualities quickly and browse them for heterogeneous terminals for video resolutions, it is needed that users keep them in user terminals themselves. Here, the number of layered structure is set to two. First, information data of proposed system is defined. In this system, we use content data and index information. Data structure is scalable, and index data has IDs, qualities, usage time and so on.

A. Data transition process

We explain the data transition method which is used in management systems. Generally, they use the reduction method for disused contents to save their contents in local hard disk of users' terminals, which have limited storage capacity. If the system does not have the functionality of the auto reduction, we cannot record our video clips, or the scheduled program does not work well. From the viewpoint of the user terminal, the condition of this system is considered. Users want to keep as many contents as possible themselves after purchase, because they watch some contents at any time and they would like to play some contents again. They think that the convenience of service is important. Moreover, they require the model that the lack of information can be acquired quickly by on-demand services. The re-use contents' data should be reduced temporally, or moved to the other device.

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For these issues, in this study, the whole data of the content is not reduced, but the part data of its content only is done by scalable structure. We use scalable video coding architecture, such as, spatial scalability, SNR scalability and temporal scalability, etc. in international coding standard MEPG-2, MPEG-4 [7][8][9]. The gradual data by data transition process consists of layered coding architecture and the procedure of data transition is proposed and adapted to the content management system.

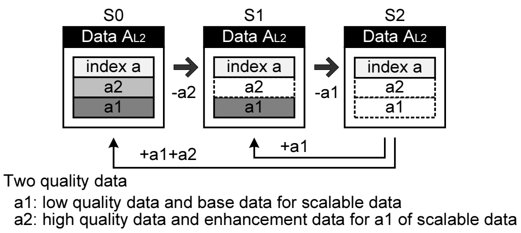

Figure 1. Data transition of scalable structure

Fig. 1 shows the data transition process and their status. The status S0 shows the data structure of high quality, H and I. H is two layered data, and it has base layer of low quality (a1) and enhancement layer of high quality (a2). L is only a1 for low quality. I information is index information. The data structure is lower quality progressively from left to right. The right status has only index information. In addition, there are the number of layer for content quality, current status of data and content data itself, as management information. According to the order of contents' priority, we reduce the data quality and its data structure is changed from the original data structure of used data to right data. On the other hand, if users access to high quality, the status is moved to the left side. Here, scalable structure can adapt to the different quality representation for heterogeneous terminals.

B. Procedure of data transition

The procedure of data transition is explained. The determination process of data transition uses the value function and the status of local disk space. The order calculated by the value function also decides the reduction scheme in the management method. The definition of basic priority function based on data transition of scalable data structure according to elapsed time is shown by Fig. 2.

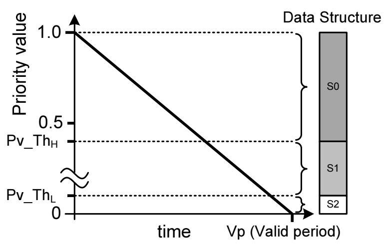

Figure 2. The priority function based on the elapsed time and the status of data structure

We simply show that the figure indicates monotonic decrease. It also shows that the value is related to the elapsed time. The longer the elapsed time from the access time is, the lower its value is. When they use the high quality content, the data status becomes S0. Meanwhile, when low quality, it becomes S1. When they do not use them periodically, it is S2. It is the model when the number of use increases, the value is high.

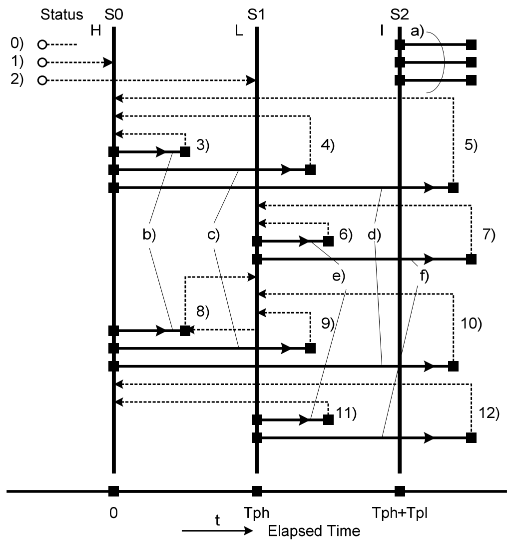

Figure 3. Updating process of used elapsed time for some quality contents and transition state

Final data transition is determined by the judgment of the priority calculated by the value function, some thresholds, and the utilization condition of local disk in user terminal. According to the space of local disk, it is decided whether the action actually is performed or not. The content status transits from high level to low level, S0, S1, S2 in turn, based on the order of the priority. Actually, the reduced target content is calculated by usage history of contents and the frequency of use. At this time, the utilization time table is used, and the priority order becomes low for long term of elapsed time. The high level transition is based on the usage of high quality. Fig. 3 shows the relationship of updating process of elapsed time from used time for some quality and transition state. The horizontal axis shows an elapsed time, and repeated use is important to keep the data status in local device. The upper data level is decided by use of the high quality. In this figure, a)-f) show the transition status after use, and 0)-12) show the updating status of quality selection. The group of a) shows S2 of initialized data. b): S0, c): S1, d): S2, e): S1, f): S2, g): S1. On the other hand, 0): No use, 1): High quality use, 2): Low quality use. 3) 4) 5) 11) 12) show that stored data return to the S0 structure after data transition, respectively. 6)-10) also show that stored data return to the S1. For instance, in 3), when they use H, the status is S0 and t=0 is set.

C. Procedure of data management method

Next, the content management procedure in local disk of user terminal is shown by Fig. 4. We simply explain the flow.

In a periodical time, we check the number of the contents and the disk space in local disk. However, in the case where the content does not exist in local device and in the case where the data space is sufficient, the data transition process is suspended. The order of the content priority is calculated by some information, such as, usage history, frequency, quality, and the value function using elapsed time. We treat the current time and the used time of contents, and manage the time information and disk space for stored contents. The target number of reducing is calculated by disk space, and the data transition process is repeated until the disk space of new contents satisfies a threshold value. Finally, the content management method based on data transition is useful. You can see that the old contents, which are not available, are reduced in local disk. Here, these processes are treated as the first process at stated intervals. Some samples of the parameters of target contents are shown. Content data size: D_p[bit], Quality: H:*a1+a2*, L:*a1*, *a1=a2*, the disk capacity in user terminal: *S*[bit]. For *x*[week], N_u: the summation of the number of usage, *y*:limited number, C_{ux}: the number of usage in one interval. The check functions of the number are defined by countH, countL, countI for high, low data and index information respectively. In this study, we put the frequency ahead of the elapsed time and the priority function is used for renewal period. If the renewal period is long, the frequency information is important. Meanwhile, if it is short, the time data is considered. The detail setting of the function is the further study.

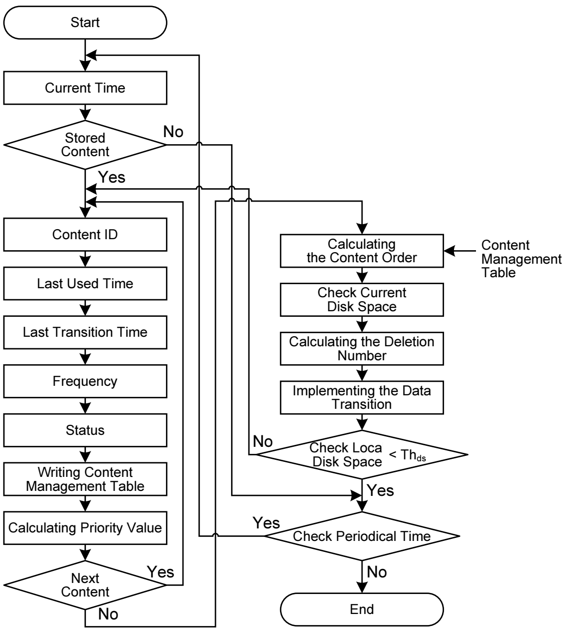

Figure 4. The procedure of content manage method

$$\begin{cases} Pc(x) = countH(x-1) + g\ countL(x-1) \\ \qquad -y + k \cdot N_u\,(x-1)/(x-1) \\ N_u(x-1) = \sum_{n=1}^{x-1} Cu_n \end{cases} \quad (1)$$

The calculating function of the target transition number: Pc(x) is defined by equation (1). Here, g = a2/(a1+a2)=1/2. In this function, when *Pc(x)>0*, the data transition process is performed according to the rank of the priority. Otherwise, the process is suspended.

III. CONTENT USAGE MODEL

The content utilization services and the usage models are described.

A. Service model

We think two hierarchical qualities as the content services. In high quality video, users watch home-TV in large-sized monitor, and they use mobile-TV in low quality video. In addition, when they also browse video contents, low quality data is used. They become a member of either-or content service of the quality, or both. Here, when they download the content, which is required, after the data is temporally stored in home server, it moves to user terminal, such as, home TV terminal and mobile TV terminal. That is to say, the home server relays their contents to user terminals.

We can consider that there are three utilization forms, UT_m, UT_n and UT_o for two qualities as services models. In this figure, the gray color means no members. Moreover, once users store the contents in local disk of user terminals, they play them. The service model is shown by Fig. 5.

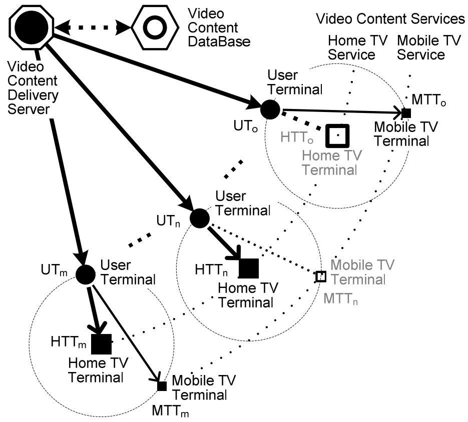

Figure 5. Service model

B. Utilization model

In this service, the simple access model for multi-quality selection is defined by Fig. 6. Users start utilization services, and browse the content list. After that, they actually browse some contents shortly. If you need the contents to browse them, the contents in local disk are retrieved. However, if not, the contents are downloaded from the server. They select the content number, and the quality in the determination processes. If they can find that in local terminal, they proceed to the play process. If they cannot, they proceed to the next process. They check the status of contents and the quality in local terminals. After the content search, calculating process of the different data and data transmission in turn, they update the status and index information for the content management. In the data exchange between the server and clients, once they execute login procedures, they access to the server. After they retrieve the contents by download process, they play them at any time. If they repeat to select, they return to browse. Otherwise, they finish the service. Moreover, we suppose that this system has two information management processors in both the server and user terminals. They can exactly know the current status of the contents, the frequency and the elapsed time from the access time for every user. Therefore, the status by scalable structure is changed according to the elapsed time and the utilization of the quality.

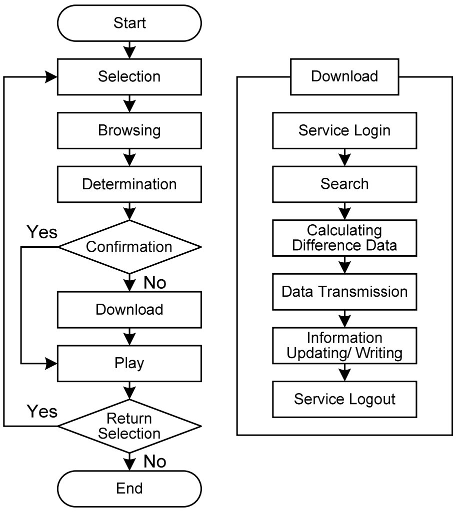

Figure 6. Access model

IV. CONSIDERATION

Firstly, we define the utilization condition in proposed method. Next, the efficiency of this system is considered.

A. Conditions

Suppose that this system transmits the contents to each Terminal (HTT, MTT in Fig.5) for each quality. One of users plays the required content according to the above statement. We assume that he uses them in quantities of C_u units of average times per an interval, and the quantity of servers' contents is enough to use. However, we do not treat the user tastes of the contents in this study. The number of browsing the contents is z units, before selecting. The number of z is depended on usage history and the status of storage. Moreover, he uses the low quality data each to browse them, which are stored in local disk. When the data is not stored in the local disk, the part of content data corresponding to only browsing is transmitted from the server to the user terminal. The amount of content information is D_p[bit], the play time is D_a[s] and the browsing time is D_b[s]. The speed of transmission for users is W[bps].

$$\begin{cases} T_{service} = T_{selection} + T_{browsing} + T_{Determination} \\ \qquad + T_{confirmation} + T_{Download} \\ T_{download} = T_{search} + T_{datatransmission} + T_{updating} \end{cases} \quad (2)$$

Next, the required time of retrieving service is defined bellow. It does not have the play time, and he plays the content, after the download process. As the required times which everyone cannot ignore, there are browsing time and data transmission time. The browsing time of T_p is shown by $D_b \cdot z$. The transmission time to play one content is D_p/W, the transmission time to browse it, T_b is shown by $T_b \leq z \cdot D_b/D_a \cdot D_p/W$ and $T_{browsing} = T_b + T_p$. Therefore, the summation shows the whole service time. It is the point that the rate of retrieving the low quality of stored content and the hit ratio are intimately related to the service time. The other processing times are ignored. The service times are described by equation (3).

$$\begin{cases} T_{service}1 = z \cdot D_b + \left(z \frac{D_b}{D_a} D_p + D_p\right)/W \\ T_{service}2 = z \cdot D_b + \left\{(z - z_h - 1) \frac{D_b}{D_a} D_p + D_p\right\}/W \\ T_{service}3 = z \cdot D_b + \left\{(z - z_h) \frac{D_b}{D_a} D_p + D_d\right\}/W \\ D_d = \begin{cases} 0 & (D_p \in S0) \\ g\,D_p & (D_p \in S1) \\ D_p & (D_p \in S2) \end{cases} \end{cases} \quad (3)$$

The service time 1 shows the case of no hit of use history. The second is shown that the content of use does not match the download content, but it hits the browsing contents. The third is shown that it matches the browsing contents without the download content. You can know that D_d of amount of the transmission data is changed by the status. z_h is the number of hit contents. If the service time is long, the cost is high. When we consider the situations, we divide into two main cases, the case of utilization of single quality, and the case of utilization of multiple qualities both. In this study, theoretical approach is explained, but the experimental approach is future tasks.

B. Single quality use

This case is applied to the situation of UT_n, UT_o defined by the service system. In single quality use, L has two transition statuses and H has three transition statuses. The former boils down to the problem whether the contents are cached or not. On the other hand, the latter is related to the solution whether it is efficient or not when the part data of the contents is cached.

At first, we consider the first problem to simplify the problem. It is indicated that the management method using the frequency of use is generally useful by reference [5]. Meanwhile, it is the point whether the efficiency of caching method partly can be expected. Here, data size of a1 is the same as a2.

Here, for example, we consider the model in a uniform access model as content services. In this case, the every probability of the content is the same. Therefore, if the status of H moves to the a1, the rate of occupation in the used contents is reduced by half.

We consider the uniform model in detail here. The frequency function of content hit ratio is uniform and the smaller the amount of transmission data is gradually, the larger the probability is. The summation of the transmission for no hit content is defined by next equation.

$$g(p) = D_{Tra}(0, N)(1 - p) = A(1 - p) \quad (4)$$
$$A = D_{Tra}(0, N)$$

$$h(p) = (1 - p)D_{Tra}(0, N) + pD_{Tra}(1, N) \quad (5)$$
$$= A(1 - p) + Bp$$
$$A = D_{Tra}(0, N), \quad B = D_{Tra}(1, N)$$

The equation of the ratio of hierarchal data is shown.

$$f(p) = (1 - q)g(p) + qh(p) \quad (6)$$

Therefore, when we use Px, Py, the function are described.

$$f(P_x, Q_x) = (1 - Q_x)\, g(P_x) + Q_x h(P_x) \quad (7)$$
$$f(P_y, Q_y) = (1 - Q_y)\, g(P_y) + Q_y h(P_y) \quad (8)$$

The difference function r(P) between h() and g() shows next equation.

$$r(P_x) = h(P_x) - g(P_x) \quad (9)$$
$$= A(1 - P_x) + BP_x - A(1 - P_x) = BP_x$$

We arrange the conditions for above mentioned situation. The hit ratio of cached content by structure G is constant.

$$r(P_x)(1 - Q_x) = r(P_y)(1 - Q_y) \quad (10)$$
$$BP_x(1 - Q_x) = BP_y(1 - Q_y)$$
$$\therefore\ P_x = \frac{1 - Q_y}{1 - Q_x} P_y, \quad P_y = \frac{1 - Q_x}{1 - Q_y} P_x$$
$$Q_y = 1 - \frac{1 - Q_x}{P_y} P_x, \quad Q_x = 1 - \frac{1 - Q_y}{P_x} P_y$$

Here, the amount of content itself is defined by $D_G = D_{SS}$.

$$D_{SS} = D_L + D_H \quad (11)$$

The summation of the transmission used hierarchical hit ratio P_{ss} for the number of n is described.

$$D_{Tra}(0, N) = \sum_{n=1}^{N} D_G(n) = ND_G \quad (12)$$
$$D_{Tra}(1, N) = \sum_{n=1}^{N} D_H(n) = ND_H$$
$$A = ND_G, \quad B = ND_H$$
$$\therefore\ A = \frac{D_G}{D_H} B$$

There are the similarity relationship between the gained number of hit ratio and the rate.

$$r(P_x)Q_x \times P_x Q_x \frac{D_H + D_L}{D_L} = r(P_y)Q_y \times P_x Q_x \quad (13)$$
$$\therefore\ P_y = \frac{Q_x(D_H + D_L)}{Q_y D_L} P_x$$

By equation (10)(13),

$$P_y = \frac{1 - Q_x}{1 - Q_y} P_x, \quad P_y = \frac{Q_x(D_H + D_L)}{Q_y D_L} P_x \quad (14)$$
$$\therefore\ Q_y = \frac{Q_x(D_H + D_L)}{D_H Q_x + D_L}$$

The condition of advantage of hierarchical allocation method is $g(P_x) \geq f(P_y, Q_y)$. This means that the transmission data after moving is able to be reduced. The summation D_{Tra} of the transmission in each content is defined by the function f() for the change of structure allocation.

$$g(P_x) - f(P_y, Q_y) = A(P_y - P_x) - BQ_y P_y \quad (15)$$

If equation (13)(14) are used,

$$= A\left(\frac{Q_x(D_H + D_L)}{Q_y D_L} P_x - P_x\right) - BQ_y \times \frac{Q_x(D_H + D_L)}{Q_y D_L} P_x \quad (16)$$
$$= P_x\left\{A\left(\frac{Q_x(D_H + D_L)}{Q_y D_L} - 1\right) - B\frac{D_H + D_L}{D_L} Q_x\right\}$$
$$= P_x\left\{A\left(\frac{Q_x(D_H + D_L)}{\frac{Q_x(D_H + D_L)}{D_H Q_x + D_L} D_L} - 1\right) - B\frac{D_H + D_L}{D_L} Q_x\right\}$$
$$= P_x\left\{A\left(\frac{D_H Q_x + D_L}{D_L} - 1\right) - B\frac{D_H + D_L}{D_L} Q_x\right\}$$
$$= \frac{P_x Q_x}{D_L}\{AD_H - B(D_L + D_H)\} \quad \geq 0$$
$$\therefore\ A \geq \frac{D_H + D_L}{D_H} B$$

Thus, $D_G \geq D_L + D_H$ by equation (12)(16). You can know that the equality only meets conditions. We consider this condition is not available for hierarchical data. Figure 7 shows the relationship between transmission data and the probability of hit contents for cached contents. In this figure, the larger the ratio of hierarchical allocation is, the larger the summation of the transmission data by the probability of access. On the other hand, the smaller the ratio of hierarchical allocation, the lower the vertical value is. The higher the transmission data is for vertical axis, the larger the probability of hit is. In the other word, if q is bigger, there is the space of disk for cached contents, and the number of stored contents is larger. Therefore, the status is moved to right point. Meanwhile, the lower the transmission data is, the smaller the hit rate is because of decreasing scalable data. Since the movement by decreasing is occurred according to the slope of g(t), the gradient is high and the rate of increasing the summation is also high. However, you can understand that there is no transition of scalable data structure for the condition.

This case is the uniform access model of used contents. Thus, the equal access for each content if you use the limited capacity of cached disk, full cached data structure is good. That is to say, it is better when non scalable structure is used.

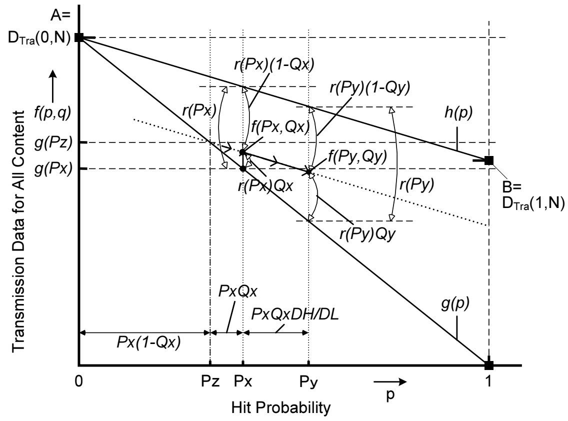

Figure 7. Relationship between transmission data and the probability of hit contents for cached contents

Consequently, to have an advantage, the processes only have to double the hit ratio. However, the ratio is not more than twice in theory. Thus, there is no case when the efficiency of the transmission is improved. Next, we take up the model that the popularity of content access centers on some contents. In the same way, even if the number of stored contents is increased, the efficiency is not more useful. However, you can know that the browsing time is shorter by these processes. As mentioned above, for the purpose of reduction of data transmission, this system is insignificant.

C. Multiple qualities use

This case is applied to the situation of UT_m defined by the service system. We do not treat the situation of single quality for services.

By Fig. 3, there are two cases that they use the low quality after high quality: 8) 9) 10), and that they use the high quality after low quality: 11) 12). When the status S1 is changed to S0, it is the same as previous study [6]. It showed that the transmission of the difference data is efficient in content

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distribution systems. Moreover, the statuses of the actual transition are 10)11)12). T_e is defined as the elapsed time from the request of the content in 10). Considering the transition time, $T_e \geq T_{ph} + T_{pl}$.

The way we can meet the conditions in 11) 12) is to set that T_{pl} is larger. We can say that it is available, if they reuse and browse the contents while the elapsed time is less than T_{pl}. Consequently, if we define that T_{pl} is larger than T_{ph}, the probability of contents' hit is higher and this system has an advantage of data transition. In this way, considering the worth of time domain, if this system manages the content and the information for the quality, it is better than previous study, which uses the independent data for some multiple qualities. We can summarize that the efficiency of the data management is not expected by data transition process for only a member of Home TV. It is the same way in Mobile TV. On the other hand, if both qualities are used, when the number of the used content is hit for valid period of the status, or when the used content is matched to the browsing one, this system is more available by proposed methods. Since we can use that stored data to browse the content, the cost of service is lower.

V. CONCLUSIONS

In this paper, we proposed the content management method using data transition for multiple qualities in video content distributed system. Users freely use the content for multiple qualities, and the elapsed time is used to reduce the unnecessary data in proposed methods. We explain the procedure of data transition, and consider the cases of the improvement of convenience and the low cost.

In prospective conditions of the number of low quality used contents, when they use the content of multiple qualities, if the transition time is set to be long, proposed method is efficient. In addition, when they do not use the multiple qualities, it cannot be expected to reduce the transmission data. However, there is some advantage of browsing.

As the further studies, we continue to consider the detail models for multi-quality video, and evaluate the proposed system using access models in some experiments.

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